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On the Development of Caligus hyalinus Chrnew.

(With one plate of drawings).

By V.I.Ulyanina.

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In 1835, Burmeister *) found near Helgoland upon a mackerel an unusual form of Caligus differing from all the forms known until then, in addition to certain minor features mainly in the presence upon the centre of the frontal edge of a long process, sectioned at the base; the parasite was attached by means of this process to the animal at the expense of which it existed. Because of these peculiarities of organization and because of the peculiarities in the way of life connected with the above, Burmeister felt himself obliged

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*) Beschreibung einiger neuen oder wenig bekannten Schmarotzenkrebse, nebst allgemeinen Betrachtungen über die Gruppe, welcher sie angehören (Nova Acta Ac.Leop.Car. XVII. I 1835).

to form a new genus for this unusual Caligus; he named this genus - Chalimus.

But already shortly later (in 1837) Krøyer expressed doubt in the virtue of this genus *); according to Krøyer Chalimus is merely a stage in the development of any Caligus. Later, Franz Müller succeeded to confirm Krøyer's hypothesis through his observations. **)

If we add to the above, the observations of Hess consisting in the information that the stage with a process upon the forehead is sometimes found attached not to the animal at whose expense the parasite lives, but to the adults of the freely moving individuals of the same species of the parasite ***), then we have mentioned all the information concerning the development of the Caligus known until now. One stationary stage is known, which is similar in many respects to the corresponding stages of other parasitic

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*) Concerning the parasitic crustaceans, particularly in respect to the Danish fauna ("Naturhistorisk Tidskrift" /Journal of Natural History/ published by H.Krøyer. First Volume, 1837. Page 201. Note 2).

**) Eine Beobachtung in Beziehung der Gattungen Caligus und Chalimus (Wiegemann's Archiv für die Naturgeschichte. XVIII. 1852. I. Page 91.).

***) Mémoire sue les moyens à l'aide desquels certains crustacés parasites assurent la conversation de leur espece (Annales des Sciences Nat.IV. Serie. IX. 1858. Zoologie. page 120.).

crustaceans (lernaea); this resemblance of the stationary stage of the Caligus with similar stages of lernaea permits us to assume that the Caligus'es also have other stages through which the lernaea pass, - namely: the nauplius and the cyclopoid stages, but such an assumption has still not been confirmed by observations. To confirm these assumptions and partly to fill out the blanks in the already existing information on the development process of the Caligus is the purpose of the present article.

My observations are established for the species Caligus occurring in abundance along the entire northern coast of the Black Sea and which was described by G.Chernyavsky under the name of C.hyalinus from one specimen that he found swimming freely in ~~the~~ Yalta bay. *) I found this species in considerable numbers and at various stages of development on the fins of Crenilabrus ocellatus and less frequent on the fins of Cr.griseus. During my stay at the Black Sea (in Sevastopol, summer of 1869), being occupied by different work, I was able to study the available live material only

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*) "Materialy dlya sravnitelnoy zoografii Ponta."/Material for comparative zoography of the Black Sea/. Page 56, Plate VIII, fig. 45-46 (In the Transactions of the First Congress of Russian Naturalists in St.Petersburg, 1868.)

occasionally. I had only opportunity to undertake more detailed studies after my return to Moscow, where I could study specimens in alcohol collected in sufficient quantities by me in Sevastopol, as well as by M.Yu. Poggenpol in Feodosia and Kerch.

Cyclopoid larva (fig. 1) is the earliest stage observed by me; it often occurs attached to the fins of the mentioned fish. The body of this larva, just as the body of the cyclopoid larvae of Achteres and Lernaea consists of two parts sharply delineated from each other: the front part which is wide and corresponds to the head and the front segment of the thorax, and of the rear one, which is narrowed and consists of four distinctly delineated segments, the rear one of which carries furcae with long setae. Two pairs of antennae are arranged upon the front edge of the cephalothorax. The antennae of the front pair adjoin closely to the front edge of the cephalothoracic carapace (fig. 1, 6a) and consist of two segments of which the first one is almost twice as long as the second. On the front edge of the first segment, as well as at the end of the second one are several setae among which I was unable to detect any tactile filaments. The antennae of the second pair arranged upon the ventral side of the cephalothoracic carapace, at the very front edge of which, the consist each of two monosegmental branches (fig. 1, 6bc). Both branches have pear-like shape and each has on its end heavily developed and curved hooks by means of which the larva attaches itself mainly to the animal upon which

it lives. One of the branches of these antennae of the second pair is developed much stronger than the other branch /p.62/ and protrudes far beyond the front edge of the cephalothorax (fig. 6b); the second one, the less developed branch does not protrude beyond the front edge of the cephalothorax and is arranged at a right angle to the more developed branch (fig. 6c).

On the front edge of the cephalothorax, between two pairs of antennae, one discerns in certain larvae of this stage, an extremely weakly delineated rounded process, equipped on its ventral side with a needle (fig. 1, 6) also weakly delineated. The significance of this process, as well as of the needle upon it remains unknown to me; they are found exclusively in young larvae of this stage, thus exactly in larvae in which the origin of the attachment organ, characterizing the subsequent stages, is still not observed.

On the ventral side of the front half of the cephalothorax is the oral conus which is always turned forwards (fig. 1 m). Both pairs of jaws are outside of the conus; the front pair (fig. 7 mbb) appears as a small mono-sectional process with a small curved brush at the end; the jaws of the second pair (mx) consist of two monosectional branches equipped with brushes at their ends. The free edge of the oral conus is equipped with heavily developed chitine teeth (d).

To the sides and below the oral conus are arranged two pairs of indistinctly two-sectional maxillipeds (fig. 1 e, 1)

also adapted for the attachment of the larva to outside objects. The rear pair of the maxillipeds is longer and thinner than the front one (fig. 8, 9).

Two pairs of biramose swimmerets (fig. 1 gh) are attached: first pair - to the rear edge of the cephalothorax, to the first thoracic segment constituting the cephalothorax; second pair, however, - to the second thoracic segment - - to the first segment of the narrowed rear portion of the larva. Each of these legs (fig. 10) consists of a basic wide plate (1) and the two terminal rounded plates (2, 3) equipped with a high number of rather long setae.

The second segment of the narrowed rear portion of the larva (the third thoracic segment) is widened at the rear and is equipped with two setae in each corner of its rear edge (fig. 1, 2); the fourth thoracic segment (k) which follows this segment, is short and rounded at the edges; it is finally followed by a large, almost square ventral segment carrying two plates of the furca, each of which is equipped with six strongly developed setae arranged fan-wise.

Two eyes with dark-red pigmentation (fig. 3, 4, 5 oc) are arranged upon the dorsal side of the cephalothorax, approximately at the spot, where the oral conus begins on the ventral side.

Such a larva is usually found attached to the fins of Crenilabrus by means of either the second pair of antennae,

or by maxillipeds equipped with hooks. On the dorsal side of some of these larvae, evidently the older ones, in front of the eyes already is visible the forming attachment organ - the flagellum (fig. 3, 4, 5 hft), by means of which the subsequent stage is attached to the fish. This stage, into which the larva has to change, is the Chalimus -stage.

Just as in the larvae of Achteres percarum, a heavily refracting attachment organ is formed in the fine-grained mass located in front of the eyes of the larva. This fine--grained mass decreases with the development of the attachment organ, but may still be distinctly noted in the stage illustrated by me on fig. 5 (y). As we see from the drawings 3, 4 and 5, the attachment organ originates right from the beginning in two halves distinguishable even in the already fully formed flagellum during all the stages of Chalimus.

The cyclopoid larva, having shed its skin, changes into a wide and flat larva, which right from the start is recognizeable as Caligus. The widened frontal part of the larva acquires a pear-like shape: to its narrow front end is attached the attachment organ, originated and formed during the preceding stage; by means of this organ the larva is securely attached to a fish. With this stage begins a whole number (five) of immobile stages (stages of Chalimus) that are analogous to the Lernaea stages, in which

it is mainly the number, as well as the structure of the sectional body appendages, that fluctuate. Just as in the pupa-stages of the lernaea, the organs of these stationary--living larvae, which served for the locomotion purposes of the cyclonoid larva, lose almost entirely both their segmentation, and their seta-equipment. Identically, the organs that served the cyclopoid larva as attachment to fish, are also decreasing in size, changing their position upon the body, and are gradually losing the hooks and catches necessary to the attachment organs.

In the first Chalimus stage (fig. 11) the cephalothorax appears like a flat pear-shaped carapace to the narrowed front edge of which the flagellum of the larva is attached. The frontal lobe is still not discernable in this stage; both antanna-pairs has receded far from the front edge of the body on the ventral surface; it has two pairs of swimmerets similarly to the cyclonoid larva, but no segmentation at all may be discerned and the seta-equipment is very poor (fig. 12).

In the subsequent stage (fig. 13) we may already discern the formed forehead lobe upon the front edge of the cephalothorax; the first antenna-pair retains the same position and the same shape, as in the preceding stage; however, the second pair changes much in its appearance and approaches the shape of the same organ in an adult Caligus. This stage has alredy three pairs of swimmerets, but the

third pair is represented merely by a simple process.

The third stage of Chalimus differs from the second one only in the appearance of the embryo of the fourth pair of swimmerets and in the further development of the third pair. The notches upon both sides of the front part of the cephalothorax become more pronounced and the frontal lobe is pronounced still more distinctly.

In the fourth stage of Chalimus (fig. 14) in addition to heavy development of the fourth pair of swimmerets that have appeared as embryo in the preceding stage, we observe the appearance of the segmentation of all the other legs. Thus in the second pair of legs two branches are distinguished, the external one of these already consists of two, although not distinctly separate, but still distinct segments; the third pair also acquires a widely-bobate shape characteristic of the adult Caligus. Finally, in the first pair, which is monoramose in an adult animal, the interior branch begins to decrease in this stage to disappear completely in the next - the fifth - stage of the Chalimus. The fourth pair of legs still remains very little developed, no segmentation can yet be observed in neither branch of this last-emerged pair.

In the fifth - the last - stage of Chalimus (fig. 15) this fourth pair of legs also loses its regular biramose shape; the exterior branch appears during this stage considerably heavier developed than the interior one; in adult

animals, this interior branch is represented only by a small process equipped with large seta arranged upon the interior side of the point of the basal segment of the leg. The fifth pair of legs originates in this stage upon the second--last segment like two small processes with a few setae upon them. This pair of legs remains unchanged in the adult animal.

In this last stage of Chalimus also takes place the separation of the lower branch of the second pair of antennae from their second and larger branch; in adult animals this separated portion of the rear antennae moves still further away from the former. In adult animal it was described under various names: Krøyer - humulus subsidiarius, Chernyavsky -- appendix hamata and other names.

Among all the changes taking place in the body of a larva during the development of Caligus, I believe two changes deserve special attention: 1) the formation of the frontal (forehead) lobe and its relation to the first pair of antennae, and 2) the method and the causes of the formation of the segmentation observed in ~~old~~ advanced Chalimus ~~es~~ ~~upon~~ of the flagellum by means of which they are attached to the fish. I permit myself, therefore, to discus in some detail these two points in the development history of Caligus.

The origin of the frontal lobe in adult Caligus is usually explained by merger of two basal segments of the front pair of antenna, both to each other, and with the front

edge of the cephalothoracic carapace. The depression observed in many Caligidae in the middle of the front edge of this lobe, is usually accepted as indication of such a merger. The justtification of such a viewpoint upon the origin of the frontall lobe in Caligidae, is not based upon the development histtory of the Caligidae, but exclusively upon the study of adult animals, in which, in many cases the position of the antennae in relation to the lobe and the depression in the middle of the front edge of the lobe, actually appear to support the above opinion, - this justification seems to me dubious to the highest degree. However, there is nothing easier than to convince oneself studying the larvae of various stages of Caligus, that the frontal lobe is formed completely independently, that according to its origin, it is nothing more than a slightly segregated portion of the cephalothoracic carapace, and finally, that the front pair of antennae in an adult Caligus consists of the same segments as in the cyclonoid larva and in the various stages of Chalimus. In the first Chalimus stage, the antennae of the first pair move heavily to the rear from the front edge of the animal, and they maintain this position in all the subsequent stages, as well as in the adult animal; the front edge of the cephalothorax changes strongly in outline and soon achieves the shape of the lobe characteristic of the Caligidae.

What concerns the depression observed in the middle of the front edge of this lobe, I have reason to assume, that

its presence in the adult animal is caused by the attachment organ that is attached in the preceding stages to this point of the cephalothorax.

In the first stage of Chalimus the attachment organ appears as a flagellum equally thick along its entire length, which is heawily light refractant, and clearly consisting of two halves, that may be distinguished already in the very beginning of its formation in the cyclonoid larva. The segmentation is still not observable at the origination of the flagellum; at its origination both halves of which it is constituted deviate from each other and are attached to the cuticula covering the larva (fig. 11, 17 n.) with what looks like two small roots.

Prior to the transition into the second stage of Chalimus, under the cuticula covering the larva of the first stage, as always, a new cuticula is formed; this new cuticula is clearly distinguished in larvae that are ready soon to shed their skin. At the front end of this new larva, which is almost ready to shed its old skin, right under the very organ of attachment, a depression in the cutucula is noticeable; at the bottom of this depression, an elongatedly-round body is formed that is divided in two along the longitudinal axis; this body refracts the light to the same degree as the attachment organ itself. (fig. 13 hft.).

Follow-up of the further changes of this body arranged below the flagellum, indicates that it is nothing but a

newly formed attachment organ of the subsequent second stage of Chalimus; in the course of its growth, it approaches little by little to the rear end of the flagellum of the larva of the first stage and unites finally with this end; /p.64/ when shedding, the cuticula covering the animal and with which it is, as mentioned above, in contact by means of the flagellum roots, this cuticula detaches itself from the latter and the next stage of Chalimus turns out after the shedding to be still attached to the fish by means of the very same flagellum as in the preceding stage; but this flagellum became longer by means of addition to it of the new stage's attachment organ newly formed and merged to this flagellum; it appears to be segmented at the base; the connection causing this segmentation is at the merging point between the old portion of the attachment organ and the portion of the very same organ that is formed anew. Both upon the old, and upon the new portion of the flagellum one may distinguish both the body proper of the flagellum, and the roots: among the latter, naturally, only those that belong to the newly formed portion are connected to the cuticula covering the animal (fig. 13, 14, 15).

The described process is repeated without any changes at any shedding of the Chalimus stages. Each shedding leaves a doubtless evidence about itself in the new segment at the base of the flagellum. Upon the flagella obviously shedded after the emergence of the adult animal from the last Chalimus

- stage, - upon the flagella, which often are found even with remnants of shedded cuticula attached to the fins of Crenilabrus, the number of segments is always the same, - - namely five, which fully supports the number of sheddings stated by me above, that the larvae are going through in the stationary Chalimus condition.

At the end of the last (the fifth) Chalimus stage, under the cuticula covering the larva is distinguished a newly isolated cuticula of the future adult Caligus. In the middle of the central edge of the frontal lobe (upon whose wings one is already able to distinguish papilliform depressions) below the flagellum attaching the larva to the fish, here just as in the preceding stages a depression in cuticula is formed, in which a body is originating, which refracts strongly the light and which is divided along the longitudinal direction into two halves, - a body corresponding beyond doubt to forming attachment organ of the second, third etc. stages of Chalimus (fig. 18). But with future development of the animal and with the approach of the shedding time, this body is not further developed and does not merge with the rear end of the larva's flagellum, as it took place in the preceding stages during the shedding, and conversely, it decreases continually in size, loses the welding indicating concerning its composition of two halves, and from elongated it turns into a regular round body, and both roots

distinguished in the beginning of the origination of the organ - disappear. Adult animals remaining without the flagellum which served as attachment organ in the preceding stages, turn out to be free after the completion of the last shedding and to migrate freely. In the middle, however, of the front edge of the frontal lobe a small depression remains, at the bottom of which is a heavily refracting small round body - a remnant of the ~~under~~developed attachment organ (fig. 19).

Explanation to the Illustrations.

In all the figures the same symbols indicate the same parts, namely:

a - front pair of the antennae.

b - front branch of the second pair of the antennae.

c - rear branch of the second pair of the antennae.

m - oral conus.

e - first pair of maxillipeds.

f - second pair of maxillipeds.

g - first pair of swimmerets.

h - second pair of swimmerets.

hfl - attachment organ.

r - roots of the attachment organ.

oc - eyes.

x - process and needle upon the front end of a cyclonoid larva.

i - process upon the thirdthoracic segment of a cyclonoid larva.

d - cuticular teeth from the free edge of the oral conus of a cyclonoid larva.

mdb - first pair of jaws.

mx - second pair of jaws.

k - fourth thoracic segment of a cyclonoid larva.

y - granular mass surrounding the formed attachment organ.

Fig. 1. Cyclonoid larva C.hyalinus Chrn. seen from the ventral side.

Fig. 2. The rear half of the body of the same larva seen from the dorsal side.

Fig. 3, 4, 5. The front half of the body of the same larva seen from the dorsal side for indication of the formation of the attachment organ.

Fig. 6. First and second pair of antennae and frontal lobe with a needle of the same larva (seen from the ventral side).

Fig. 7. Oral organs of the same larva.

Fig. 8. First pair of maxillipeds of the same larva.

Fig. 9. Second pair of maxillipeds of the same larva.

Fig. 10. Two swimmerets of the leg from the right side of the same larva: 1. - basal segment of the leg; 2. -

- exterior segment of the leg; 3 - interior segment of the leg.

Fig. 11. First stage of Chalimus seen from the ventral side.

Fig. 12. One of the swimmerets of this stage.

Fig. 13. Second stage of Chalimus seen from the ventral side.

Fig. 14. Fourth stage of Chalimus seen from the ventral side.

Fig. 15. Fifth stage of Chalimus seen from the ventral side.

Fig. 16. Rejected attachment organ after exit from the fifth stage of Chalimus of an adult Caligus.

Fig. 17. Bifurcated attachment organ found in one of the larvae of the Chalimus stage.

Fig. 18. Beginning of the formation of an attachment organ in an adult Caligus.

Fig. 19. Remnant of the attachment organ in an adult Caligus.
